Invention Disclosure

Introductory Information

Title of invention ***Calibration system for fine die alignment***

Date conceived

Inventor(s)

Name: Mike Pukmel
Address: 14 Thornton Drive
Burlington, MA. 01803

Name:
Address

Name: Harry Gao
Address:

Name: Mike Mellone
Address

Critical Dates

Prototype

Date built: 10/98 Location: 37 Broadway, Arlington, MA

Date tested: 12/98 Location: 37 Broadway, Arlington, MA

Offer(s) for sale

To: Hewlett Packard

Offer date:

Ship date: 9-98

Public disclosures

Publication:

Outsider name:

Date:

Affiliation:

Volume and page:

Background of the Invention

Problem to be solved

Product in which the invention is contemplated:

WH4100 automated backside wafer laser marker.

Brief description

The calibration system generates transformations from both 2 axis stage coordinate system, and vision coordinate system into the marking coordinate system. The vision/stage apparatus is used to locate features on the top side of a wafer, and transform the coordinates of the features on the top side into marking coordinate system on the back side of a wafer in process.

*Inventor date & initials*________________

Explanation of the problem to be solved:

The features to be located are not in view of the laser system, since they are on opposite sides of the wafer. A method had to be determined which would generate a reference point between the 2 systems (i.e. stage/vision and marker). Further, the method had to overcome errors in locations generated from the stage/camera system, due to relatively small number of pixels per unit measurement length.

Prior Art

Description of the Invention

Mike Pukmel
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Fine Die Alignment Calibration

Overview

The fine die alignment vision system is mounted on a 2 axis stage driven by stepper motors. The vision system scans the top side of a wafer to be marked when the 2 axis stage is moved. To use the system, we must first "teach" a wafer feature by moving the stage, with software programs, so that the feature of interest is visible and approximately centered in the vision field of view. We position cross hairs drawn on the vision systems bitmap on the feature and record the position of the stage. This position becomes the features "taught position", which is recorded with respect to a reference point in the vision system field of view.

At runtime, the stage is moved to the taught coordinate, and the vision system is queried for the current location of the feature. The current location, i.e. of the wafer in process, is compared to the taught location (i.e. where the cross hairs were drawn) and an offset is generated for each of 3 points. The 3 points are transformed into the marking coordinate system with a transformation generated by the calibration procedure described in this document.

The purpose of this calibration is to use the marking coordinate system as the reference. The 2 axis stage coordinates and the vision system coordinates are transformed into the marking coordinate system where the offset, and rotation are generated which indicate the actual position of the wafer in process. The reference locations are the recorded positions of features taken during the "teach" phase for a particular wafer type.

Calibration Description

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There are 2 steps involved in calibrating the fine die alignment system. First, a transformation is generated to convert 2 axis stage coordinates into marking coordinates. A second transformation is generated to convert the vision system coordinates into marking coordinates. The Fine Die Alignment system views features on the top side (featured side) of a silicon wafer in process. The marking system scribes mark jobs on the back side of the wafer (non-featured side). The back side coordinates are in the markers coordinate system. The front side coordinates are read in the xy stage and vision system coordinates, which must be transformed into the markers back side units.

Step 1: calibrating XY stage coordinates to marking coordinates
To accomplish part 1 of the calibration, we mount a mirror, silvered side down, on the marking nest. A "standard" pattern is marked on the mirror, consisting of repeated objects spread evenly across the span of the markers field of view, marked onto the bottom side of the mirror. After the mark job is scribed onto the mirror, we move the 2 axis stage to situate the vision camera over each feature (viewed from the top side of the mirror), so that the cross hairs are drawn at the same known location of each of the marked objects.

It is advantageous to center each mark job in its field, and use a symmetric object. The coordinates of each of the mark objects are recorded with the Fine Die Alignment calibration software. It is also advantageous to use the center of the vision system bitmap as a reference point, i.e. drawing the cross hairs there.

The set of coordinates used to mark the calibration job are also read into the Fine Die Alignment calibration software. The calibration software uses unconstrained least squares to generate the transformation from the 2 axis stage coordinate system into the marking coordinate system.

Step 2: vision system coordinates to marking coordinates
For part 2 of the calibration, a second "standard" marking job is marked on the bottom side of the mirror. This marking job has at least 5 symmetric objects marked with size chosen so that they can all be viewed in the vision system at one time (i.e. without moving the 2 axis stage). The 2 axis stage is moved so that all objects of the second marking job are viewed in the vision system. The fine die alignment vision software is used to locate each of the objects locations in pixels. The calibration software reads the coordinates of the set of objects (similar to what was done for the part 1 calibration step). The fine die alignment calibration program generates a transformation from pixels to marking coordinates using unconstrained least squares.

Both transformations are saved for use at runtime.

This calibration algorithm solves the problem of calibrating a laser marking system, which marks patterns on the bottom of a wafer, with an alignment system (a 2 axis stage and camera) which locate wafer features on the top side (non-marking side) of a wafer.

RUNTIME ALGORITHM

At runtime, after calibration, a wafer is placed into the marking area and held in place over the laser marking system. The XY stage is driven to each of 3 previously stored locations. The vision system is used to locate the current location of stored features on the wafer top side. The fine die alignment software transforms the coordinates of the XY stage into marker units. Next, the software transforms the vision system coordinates of the found feature, into marker units. The software then adds the vectors together to generate one

location vector, in the markers (backside) coordinate system, for each fine align point to produce "found coordinates". These transformations use the calibration polynomial calculated during the calibration steps above.

The system then calculates the predicted coordinates, in the marking system, for each of the features using knowledge of the wafer design (e.g. street widths, kerf widths, die pitch, die X and Y size etc.). Due to inaccuracies in the laser calibration, lens distortion, and laser linearization, a constrained least squares correction is applied which scales the found coordinates to the predicted coordinates. The constraint is the lengths of the sides of the polygon traced out by the alignment points in the marking coordinate system. This correction allows the system to use points from less than ½ of the wafer surface to locate and align the wafermap.

Finally, the predicted coordinates are regressed onto the corrected coordinates to generate a scale-free rotation and offset from the taught position which is sent to the marking system.

Chronological History of the Invention

Witnessed

Inventor(s)		Explained and understood by Witnesses	
Signature	Date	Signature	Date
Signature	Date	Signature	Date
Signature	Date	Signature	Date